Family Rooms in NICUs and Neonatal Outcomes: An International Survey and Linked Cohort Study

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Abstract: Objectives: To evaluate the proportion of neonatal intensive care units with facilities supporting parental presence in their infants' rooms throughout the 24-hour day (i.e., infant-parent rooms) in high-income countries and to analyze the association of this with outcomes of extremely preterm infants. Study design: In this survey and linked cohort study, we analyzed unit design and facilities for parents in 10 neonatal networks of 11 countries. We compared the composite outcome of mortality or major morbidity, length of stay, and individual morbidities between neonates admitted to units with and without infant-parent rooms by linking survey responses to patient data from the year 2015 for neonates of <29 weeks' gestation. Results: Of 331 units, 13.3% (44/331) provided infant-parent rooms. Patient-level data were available for 4662 infants admitted to 159 units in 7 networks; 28% of the infants were cared for in units with infant-parent rooms. Neonates from units with infant-parent rooms had lower odds of mortality or major morbidity (adjusted OR 0.76; 95% CI 0.64, 0.89), including lower odds of sepsis and bronchopulmonary dysplasia, than those from units without infant-parent rooms. The adjusted mean length of stay was 3.4 days shorter (95% CI -4.7, -3.1) in the units with infant-parent rooms. Conclusions: The majority of units in high-income countries lack facilities to support parents' presence in their infants' rooms 24 hours per day. The availability vs absence of infant-parent rooms was associated with lower odds of composite outcome of mortality or major morbidity and shorter length of stay.

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Family Rooms in NICUs and Neonatal Outcomes: An International Survey and Linked Cohort Study

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Data Sharing Statement: Data supporting the findings of this study are available from the corresponding author upon reasonable request.

Objectives: To evaluate the proportion of neonatal intensive care units with facilities supporting parental presence in their infants' rooms throughout the 24-hour day (i.e., infant-parent rooms) in high-income countries and to analyze the association of this with outcomes of extremely preterm infants.

Study design: In this survey and linked cohort study, we analyzed unit design and facilities for parents in 10 neonatal networks of 11 countries. We compared the composite outcome of mortality or major morbidity, length of stay, and individual morbidities between neonates admitted to units with and without infant-parent rooms by linking survey responses to patient data from the year 2015 for neonates of <29 weeks' gestation.

Results: Of 331 units, 13.3% (44/331) provided infant-parent rooms. Patient-level data were available for 4662 infants admitted to 159 units in 7 networks; 28% of the infants were cared for in units with infant-parent rooms. Neonates from units with infant-parent rooms had lower odds of mortality or major morbidity (adjusted OR 0.76; 95% CI 0.64, 0.89), including lower odds of sepsis and bronchopulmonary dysplasia, than those from units without infant-parent rooms. The adjusted mean length of stay was 3.4 days shorter (95% CI -4.7, -3.1) in the units with infant-parent rooms.

Conclusions: The majority of units in high-income countries lack facilities to support parents' presence in their infants' rooms 24 hours per day. The availability vs absence of infant-parent rooms was associated with lower odds of composite outcome of mortality or major morbidity and shorter length of stay.

There is increasing evidence for the benefits of involving parents in neonatal intensive care, which include lower stress, depression, and anxiety levels in parents (1,2,3,4); and better

cognitive (especially language) development in preterm infants (5,6). Parent-infant skin-to-skin contact has been shown to decrease mortality and infections and improve head growth (7). A cluster-randomized intervention to increase parental presence and involvement in their infant's care improved weight gain in preterm infants (8).

Parents' presence can be supported by modifying unit architecture so parents can stay in the neonatal intensive care unit (NICU) throughout the 24-hour day. The opportunity for parents to stay overnight with their infants in the NICU can be achieved with single-family room model but may also be achieved with a wide variety of design solutions not limited to single-family rooms. Single-family rooms have been shown to associate with lower rates of infections (5,9), shorter length of stay (10), better production of maternal breast milk, and improved cognitive and language outcomes for very low birth weight infants (6) compared with units without single-family rooms. Other NICU designs offering the opportunity for parents to stay with their infant in the NICU have been shown to encourage parental presence (11). Therefore, this study focused on the availability of infant-parent rooms, defined as facilities for parents to stay 24 hours per day with their infants.

The International Network for Evaluating Outcomes of Neonates (iNeo) is a multinational collaboration of national or regional neonatal data networks including 11 countries. It provides a platform for comparative evaluation of the care environment and outcomes of extremely preterm infants and very low birth weight infants at the national, site, and patient levels; and aims to improve outcomes for these infants. (12,13,14).

Our objectives for this international study were to survey NICU facilities for parents and assess whether the availability of infant-parent rooms, allowing parents to stay 24 hours per day with their infants, is associated at the patient level with the composite outcome of mortality or any major morbidity or with the length of stay in hospital. In secondary analyses, we studied each morbidity individually. We hypothesized that availability of infant-parent rooms is associated with improvements in the medical outcomes.

Methods

We created a web-based survey including several questions with pre-defined answer options related to NICU facilities. The survey was pre-piloted by the directors of the 10 participating iNeo networks to reach a consensus on content, relevance, and appropriateness of the possible responses. The relevant survey questions addressed unit type and size, unit design, and physical facilities for parents within or outside the unit (Appendix 2; available at www.jpeds.com). None of the questions asked was mandatory and responders could elect not to answer any question. The survey response rate was monitored on a weekly basis. A reminder questionnaire was sent twice (at a monthly interval) to units that did not respond. The survey was first sent in August 2016 and was closed by December 2016. We asked participants to respond based on how their unit was designed in the year 2015.

Online questionnaires were sent by e-mail to the directors of 10 population-based national or regional neonatal networks involved in iNeo that chose to participate in this survey; these included the Illinois Neonatal Network, which joined the iNeo collaboration for the purpose of providing survey responses but did not provide data on outcomes. The network directors forwarded the survey to the unit director or representative of each participating NICU within their network; these individuals were responsible for completing the survey. The survey was distributed to 390 NICUs participating in the following networks: Australian and New Zealand Neonatal Network (ANZNN n=28), Canadian Neonatal Network (CNN n=30), Finnish Medical Birth Register (FinMBR n=5), Illinois Neonatal Network in the United States (ILNN n=18), Israel Neonatal Network (INN n=26), Neonatal Research Network Japan (NRNJ n=204), Spanish Neonatal Network (SEN1500 n=57), Swedish National Quality Register (SNQ n=6), Swiss Neonatal Network (SwissNeoNet n=12), and Tuscany Neonatal Network in Italy

(TuscanNN n=4). All units were level 3 NICUs or mixed level 3 and level 2 NICUs providing specialized care for infants born at <29 weeks' gestational age.

Data on NICU design were reported using descriptive statistics. The distributions of survey answers within each network were described in absolute numbers or percentages for categorical variables. Patient-level data for neonates of <29 weeks' gestational age in the year 2015 were available for infants admitted to 191 units in 7 networks (CNN, FinMBR, INN, NRNJ, SNQ, SNN, TuscanNN). An infant-parent room was defined as a patient room providing parents facilities to stay 24 hour per day with their infant in the same room in the NICU; this was not necessarily a single-family room and it did not necessarily allow mother's own medical care. Morbidities included culture-proven sepsis; bronchopulmonary dysplasia (BPD), defined as supplemental oxygen at 36 weeks of post-menstrual age or discharge from unit; intraventricular hemorrhage (IVH) grades 3 or 4 or periventricular leukomalacia (PVL); and treated ROP.

Analyses

For networks and units where linkage was possible between survey responses and patient outcomes, frequencies (percentages) or means (standard deviations) were compared for neonates admitted to units with infant-parent rooms (regardless of how many such rooms there were in the unit) or without any infant-parent rooms. In an adjusted model, we compared NICU outcomes: composite of mortality or any major morbidity and length of hospital stay as primary outcomes, and individual morbidities separately as secondary outcomes. Differences between groups were assessed using the Pearson chi-squared test for categorical outcomes and the Student t-test for continuous outcomes. Multivariable logistic analyses (or general linear regressions) were applied to neonatal outcomes.

Adjusted odds ratios (aOR) and 95% confidence intervals (CI) were estimated after adjustment for gestational age, birth weight z-score, multiple birth status, sex, country, and center volume. Gestational age and birth weight z-score were treated as linear continuous variables. Center volume was categorized into big, mid-sized, or small center based on total number of infants admitted (cut offs were set at 60 infants and 30 infants).

All analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC) with a 2-sided significance level of 0.05. Seven networks allowed linkage between survey responses and unit-level patient data.

All participating networks obtained ethics/regulatory approval or the equivalent from their local research ethics committees as part of the protocol for collaborative comparisons of international health services and practices for quality improvement in neonatal care (12). Specific approval for this study was obtained from the Research Ethics Board at Mount Sinai Hospital, Toronto, Ontario, Canada, where the project was coordinated. Responders were asked to complete the survey only if they provided consent for data assimilation (unit-level survey results with unit-level patient outcomes) and anonymous reporting.

Results

Overall, 331 (85%) of the 390 contacted units responded, with response rates of 77% to 100% among participating networks. On average among the 331 responding units, 154 units (47%) cared for 20 or fewer patients per day, 69 (21%) cared for 21 to 30 patients, 53 (16%) cared for 31 to 40 patients, 22 (7%) cared for 41 to 50 patients, and 24 units (7%) cared for more than 50 patients per day.

A total of 36 (12%) units had single-patient rooms available (variability between networks ranged from 0% in Israel to 38% in Illinois). Many units (n=142; 44%) had large rooms accommodating 9 to 16 babies, and some units (n=43; 13%) had very large rooms for more than 16 neonates. Many units had a mixture of different types of rooms. **Table I** presents the distribution of available room types (by neonate capacity) across units in each of the participating networks.

Infant-parent rooms were available in 44/327 (13.4%) units (variability between networks: 0-40%) (**Table 2**). It was more common to have a room for the family just before discharge to allow them an overnight stay with their infant; 196/326 (60%) of the units provided this facility (variability between networks: 0-83%). A total of 196/326 (60%) units had a lounge for parents (variability between networks: 35-100%) and 91/326 (28%) units had a kitchen for parents (variability between networks: 0-100%). Only 2 networks had no infant-parent rooms.

The baseline characteristics of infants admitted to units with and without family rooms are presented in **Table 3**. The mean gestational age at birth was lower in infants admitted to the units with infant-parent rooms (25.8 weeks; SD 1.8) compared with infants admitted to units without infant-parent rooms (26.0 weeks; SD 1.7), $P < .01$.

Patient-level data for neonates <29 weeks' gestation in the year 2015 were available for 4662 infants admitted to 159 units in 7 networks. Of these, 28% of neonates (n=1319) were cared for in a unit with infant-parent room(s). As shown in **Table 4**, compared with infants in units with no such facilities, infants cared for in units with infant-parent rooms had lower odds of death or any major morbidity (adjusted OR 0.76; 95% CI 0.64, 0.89). In the secondary analyses for individual morbidities, infants cared for in units with infant-parent rooms had lower odds of sepsis (aOR 0.80; 95% CI 0.66, 0.97) and BPD (aOR 0.72; 95% CI 0.61, 0.86). The adjusted mean length of stay was 3.4 days shorter (95% CI -4.7, -3.1) in units with infant-parent rooms compared with those without. **Table 4** presents unadjusted and adjusted odds for the medical outcomes of infants admitted to units with and without facilities for parents to stay with their infants 24 hours per day. The most adjusted model includes the annual volume of patients per unit as a covariate.

Discussion

In this survey, 13.4% of NICUs in 10 neonatal networks representing 11 high-income countries offered facilities (infant-parent rooms) allowing parents to spend 24 hours per day in the unit with their infants. Only 2 networks had no infant-parent rooms. The availability of infant-parent rooms was associated with lower odds of composite outcome of mortality or morbidity, lower odds for sepsis and BPD, and shorter hospital stay among preterm infants of <29 weeks' gestation compared with units without infant-parent rooms.

Parents' presence in NICUs has been supported and studied using single-family rooms since the early 1990s (14). Single-family room designs, with the related changes in care, have been shown to provide benefits to infants, families, and staff (15,16,17). Our results are in concordance with a recent meta-analysis showing that preterm infants cared for in single-family rooms vs open bay units had lower odds for sepsis (18). The potential mechanisms are several, including better hygienic routines in single-family rooms and more frequent and longer skin-to-skin contact, which has been shown to associate with lower sepsis rates (7).

Our study also showed lower risk for BPD in units with infant-parent rooms. One randomized controlled trial (10) showed, consistent with our findings, lower BPD rates in infants randomized to single-family rooms compared with those treated in a traditional unit with multiple babies in one room. The mechanism behind this association is unclear. Potential explanations for the reduction in BPD include reduced infections (2,7,9,19), higher skin-to-skin care-related stability, and less fluctuations in oxygenation (7). However, a difference in the risk for BPD was not evident in a meta-analysis comparing the single-family room and open bay unit designs (18).

There are studies showing that single-family room architecture and parental involvement may be associated with shorter length of hospital stay. A randomized study in Sweden (10) showed a 10-day reduction in the length of stay among preterm infants born before 30 weeks' gestation when they received their care in a single-family room unit compared with a traditional room unit in the same hospital. In the United States, high maternal involvement in a single-family room unit was associated with a 15-day reduction in the length of stay among very preterm infants (6). However, the meta-analysis comparing single-family rooms and open bay units did not find a difference in the length of stay (18). Our study showed a statistically significant reduction in the length of stay for extremely preterm infants cared for in a unit with infant-parent rooms.

The mechanisms explaining the benefits of infant-parent rooms are unclear. As parental involvement has been shown to confer benefits for infants (5,6), we expanded our study's scope from purely single-family room architecture to include facilities allowing parents to stay throughout the day with their infants. Furthermore, designs that provide private patient rooms for preterm infants but no bed space for parents cannot be expected to yield the desired benefits. On the contrary, a study found such designs had negative effects on brain development and later cognitive development (20).

Our results support the current standards for NICU design that emphasize the social needs of infants and families (21). However, care facilities change slowly as it is costly to build new hospitals or renovate the overall layout of existing ones to include infant-parent rooms. In our survey, to compensate for the lack of infant-parent rooms, many hospitals had taken the first step to support parental presence by providing a separate room where parents could sleep in the hospital. Many hospitals provided parent support facilities, such as lounge and kitchen areas and breast pumping rooms. Such facilities are easier to integrate into existing units than are infant-

parent rooms and are likely to play a role in parental engagement and presence at the infant's bedside as they are needed for families to stay in hospital for prolonged periods. These facilities can also allow other family members, like siblings, grandparents, and other persons close to the parents, to stay in the hospital and provide their support.

Our study reports on the facilities provided to parents in 331 NICUs. Another large network, the Vermont-Oxford Network, includes more than 1200 NICUs. It has reported increasing availability of single-family rooms; 20% of its hospitals in 2016 vs 13% in 2009, provided care for 91% or more of infants in single-family rooms (defined as rooms with at least 3 full walls and a single patient or siblings) (22). Even if facilities are improving, the questions about facilities for parents do not alone tell us how much and in what ways these facilities are used. There are also variations in the definitions and designs of single-family rooms. For instance, with respect to privacy, some units have rooms with transparent walls, or just 3 full walls, to maintain visual access, whereas others rely on technology to monitor patients and provide parents private time with their infants. Some units may accommodate several patients from unrelated families in one room and still provide the parents facilities to stay overnight. In addition to the design, the quality of family-centered care plays an important role in how the physical facilities are used. Parents' presence and their role in infant care can be limited by the staff even in the context of modern architecture. The effects of unit architecture and care culture are difficult to separate as it is likely that units with infant-parent rooms have also implemented other aspects of family-centred care more widely than units without infant-parent rooms. Therefore, we need more information about factors such as how long parents stay in these units, what roles parents play in the NICU, how parental presence is affected by different unit or room designs or different

elements of family-centered care, and what roles are played by societal benefits for parents of sick newborns, including maternal and paternal leaves.

Our study has some limitations. First, we did not query the number or proportion of different types of patient rooms and we do not know which infants received the potential benefits of an infant-parent room. Therefore, an effect may have remained small because the number of infant-parent rooms was small in many units and limited the proportion of extremely preterm infants exposed to care in these facilities. We did not gather information on how these facilities were used by parents; eg, how long parents stayed in such units and what roles they played in the NICU, including skin-to-skin contact and maternal breast milk provision. The acceptability and feasibility of the survey were assessed but no psychometric testing was done for the questionnaire. Linking survey responses to patient-level data is an indirect way of comparing outcomes and could be subject to ecological fallacy. Though we adjusted for several risk factors that affect neonatal mortality and morbidity, we acknowledge that there are several background factors we could not adjust for, including the socioeconomical and ethnic backgrounds of the families, the number of staff members per patient and other NICU resources, and family-centered care practices. Finally, although many societal background factors are similar within a country, our approach of using country as a covariate can also be seen as a limitation. Despite these limitations, this international survey widens our knowledge about NICU design. Our study is among few that attempted to identify an association between unit design and neonatal outcomes. This approach provided us with information about the safety and even potential benefits of parental presence in diverse NICU settings, populations, and societal contexts. However, the survey did not provide data on the long-term developmental outcomes of the preterm infants, which is an important area for future study.

In conclusion, we found that extremely preterm infants cared for in NICUs providing facilities for parents to stay with their infants for 24 hours per day had lower odds of mortality or morbidity and shorter lengths of stay. Although the majority of hospitals did not yet offer families the opportunity to stay overnight with their sick newborns, our results indicated an increasing awareness of the rights of children to be cared for by their parents as stated by the United Nations' Convention on the Rights of the Child.

Abbreviations and Acronyms

aOR, adjusted odds ratio; BPD, bronchopulmonary dysplasia; CI, confidence interval; iNeo, International Network for Evaluating Outcomes of Neonates; IVH, intraventricular hemorrhage; NICU, neonatal intensive care unit; PVL, periventricular leukomalacia; ROP, retinopathy of prematurity

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Table 1. Distribution of Available Room Types for Neonates Across Units in 10 Networks[a]

Maximum Number of Infants per Room[b]	ANZNN n=28	CNN n=30	FinMBR n= 5	ILNN n=16	INN n=26	NRNJ n=157	SEN1500 n=48	SNN n=11	SNQ n=6	TuscanNN n=4	Total N=331
1	4 (14)	8 (27)	2 (40)	6 (38)	0	3 (2)	9 (19)	1 (9)	2 (33)	1 (25)	36 (11)
<4	6 (21)	2 (7)	2 (40)	4 (25)	3 (12)	3 (2)	6 (12)	7 (63)	4 (67)	0	37 (11)
4-6	5 (18	8 (27)	1 (20)	2 (12)	2 (8)	17 (11)	11 (23)	7 (63)	2 (33)	3 (75)	58 (18)
7-8	7 (25)	5 (17)	0	5 (31)	6 (23)	31 (20)	21 (44)	1 (9)	0	1 (25)	77 (23)
9-16	4 (14)	7 (23)	0	3 (19)	16 (62)	94 (60)	16 (33)	2 (18)	0	0	142 (43)
>16	5 (18)	3 (10)	0	1 (6)	1 (4)	30 (19)	2 (4)	0	0	1 (25)	43 (13)
Other	5 (18)	3 (10)	0	0	2 (8)	2 (1)	5 (10)	0	1 (16)	0	18 (5)

[a]All results are reported as number of units (%).

[b] Multiple responses were allowed as a unit may have many types of rooms.

Abbreviations: ANZNN, Australia and New Zealand Neonatal Network; CNN, Canadian Neonatal Network; FinMBR, Finland Medical Birth Register; ILNN, Illinois Neonatal Network; INN, Israel Neonatal Network; NRNJ, Neonatal Research Network Japan; SEN1500, Spanish Neonatal Network; SNN, Switzerland Neonatal network; SNQ, Swedish Neonatal Quality Register; TuscanNN, Tuscany Neonatal Network.

n, number of units who responded to questions in network (none of the questions were mandatory and some questions were not answered by some units).

Table 2. Unit Facilities Available for Parents in the Participating Networks[a]

Facility	ANZNN n=28	CNN n=30	FinMBR n= 5	ILNN n=16	INN n=26	NRNJ n=157	SEN1500 n=48	SNN n=11	SNQ n=6	TuscanNN n=4	Total N=331
Parent and infant together 24/7	4 (15)	6 (20)	2 (40)	3 (19)	0	20 (13)	6 (13)	1 (9)	2 (33)	0	44 (13)
Care-by-parent rooms for trial run before discharge	21 (74)	25 (83)	3 (60)	10 (63)	6 (23)	103 (66)	16 (33)	7 (64)	5 (83)	0	197 (60)
Family rooms for overnight stay	23 (82)	22 (73)	3 (60)	11 (69)	7 (27)	33 (21)	10 (20)	8 (73)	6 (100)	0	123 (37)
Parent relaxation room with beds	12 (44)	11 (37)	3 (60)	4 (25)	6 (35)	20 (13)	16 (33)	8 (73)	2 (33)	1 (25)	83 (25)
Breast milk pumping room	25 (89)	23 (76)	2 (40)	14 (88)	26 (100)	135 (86)	40 (83)	10 (91)	6 (100)	4 (100)	285 (86)
Parent lounge	26 (93)	25 (83)	5 (100)	15 (94)	23 (88)	55 (35)	29 (60)	9 (82)	6 (100)	4 (100)	197 (60)
Parent kitchen/cooking facility	22 (78)	17 (57)	5 (100)	4 (25)	16 (63)	5 (3)	13 (28)	3 (28)	6 (100)	0	91 (27)

[a] All results are reported as number of units (%); the denominator varies for different question as none of the questions were mandatory and some units did not reply to some questions.

Abbreviations: ANZNN, Australia and New Zealand Neonatal Network; CNN, Canadian Neonatal Network; FinMBR, Finland Medical birth Register; ILNN, Illinois Neonatal Network; INN, Israel Neonatal Network; NRNJ, Neonatal Research Network of Japan; SEN1500, Spanish Neonatal Network; SNN, Switzerland Neonatal network; SNQ, Swedish Neonatal Quality Register; TuscanNN, Tuscany Neonatal Network.

n, number of units in network; 24/7, 24 hours per day and 7 days per week.

Table 3. Patient-level Characteristics Comparing Neonatal Intensive Care Units With or Without Infant-Parent Rooms

Characteristics	Neonates in Units With Infant-Parent Room(s) (n=1319)	Neonates in Units Without Any Infant-Parent Rooms (n=3343)	*P* value
Gestational age, mean (SD), wks	25.8 (1.8)	26.0 (1.7)	<0.01
Birth weight z score, mean (SD)	-0.06 (0.92)	-0.10 (0.99)	0.19
Multiples, No. (%)	315 (23.9)	847 (25.3)	0.30
Male sex, No. (%)	727 (55.1)	1809 (54.2)	0.55

Abbreviation: SD, standard deviation.

Table 4. Patient-level Characteristics Comparing Neonatal Intensive Care Units with or Without Infant-Parent Rooms

Outcomes	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)	Adjusted OR[b] (95% CI)
Composite of mortality or any morbidity	0.95 (0.84, 1.08)	0.77 (0.65, 0.90)	0.76 (0.64, 0.89)
Mortality	0.85 (0.70, 1.02)	0.81 (0.64, 1.02)	0.79 (0.62, 1.00)
Sepsis	0.84 (0.71, 1.00)	0.80 (0.66, 0.98)	0.80 (0.66, 0.97)
BPD	1.10 (0.95, 1.27)	0.72 (0.61, 0.86)	0.72 (0.61, 0.86)
IVH/PVL	1.14 (0.95, 1.37)	1.09 (0.88, 1.35)	1.08 (0.87, 1.34)
ROP treatment	0.81 (0.66, 0.99)	0.91 (0.71, 1.16)	0.90 (0.70, 1.15)
Length of stay, mean (SD), days	-7.5 (-10.7, -4.4)	-4.4 (-7.8, -1.1)[c]	-3.4 (-4.7, -3.1)[c]

[a] Adjusted for gestational age, birth weight z-score, multiple birth, sex, country.

[b] Adjusted for gestational age, birth weight z-score, multiple birth, sex, country, and center volume.

[c] Coefficient (95% CI) from general linear regression.

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